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Influence of the excessive use of fertilizer on the soil attributes: A case study

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In the past few years, the increase in the population has also caused a significant increase in the demand for edible products such as cereals and vegetables. Therefore, in order to meet the demand, several types of fertilizers and pesticides have been considered in agricultural fields. The fertilizers and pesticides excel the growth of these products but at the same time, these chemical products also harm the soil characteristics such as the amount of organic matter, pH and electric conductivity, etc., due to their excessive application. By testing the soil characteristics of any agricultural field, the type and extent of treatment that is required can be evaluated. Therefore, an area of Lalri Village, Hamirpur, Himachal Pradesh has been selected to check the effects of fertilizer and pesticides on the fields of potato, peas and bitter gourd. The soil characteristics of the agricultural fields of these three crops were compared and found higher than the permissible limits. The present study aims to provide important information about the toxic effects of these chemicals on human health and the environment.

Keywords: Fertilizer, Soil, Hazardous, Organic content

INTRODUCTION

The demand of food production has been significantly increased in the past few years. More than one-third of the population of the world depends upon agriculture [1]. One-third of the world's cereal production rose from 1970 to 1980, with half of the rise in India's grain production due to greater fertilizer use [2]. It is expected that by year 2050, the consumption of nitrogen (N), phosphorus (P), and potassium (K) will grow by 172%, 175%, and 150%, respectively. Usually, fertilizers and pesticides are used to improve the growth and quality of any agricultural product, but, the uncontrolled and long-term use of fertilizers has become a major source of soil and water contamination in recent years [3, 4]. Over time, the soil of agricultural fields gets deteriorated because of the accumulation of heavy metals and other hazardous compounds as a result of excessive application of fertilizers. These toxic compounds have a greater affinity to cause harm to human health and environment [5]. It is estimated that over 10,000 casualties per year have been caused by the application of chemical fertilizers in the field in developing countries [6].

Currently, India is one of the largest producers of chemical fertilizers and pesticides with the production of 90,000 tons per year [7, 8]. Irritation to eyes and chronic health problems such as cancer, nervous system and reproductive disorders have been commonly observed in the spray workers [9, 10]. Besides the increase in the agricultural productivity, many direct and indirect negative effects have been caused by these toxic chemicals in the past few decades. In Himachal Pradesh, various types of edible products such as tomato, potato, bitter gourd, cauliflower, cabbage, pea and capsicum are grown by the farmers [11, 12]. According to a report, the consumption of NPK in the Himachal Pradesh has been increased from 7.2 kg per hectare to 10.84 kg per hectare in the past 5 years [13]. Because of the incapability of soil to absorb more nutrients, the amount of fertilizer used to distribute in the field is usually increased by the farmers during its application [14–18].

Therefore, considering the problems caused by the chemical fertilizer on human health and environment, the current case study has been undertaken to assess its impact on the three edible products such as potato, peas, and bitter gourd. The agricultural fields of Lalri village of Himachal Pradesh have been considered to evaluate the soil parameters such as pH, organic carbon and NPK. The current study also aims to provide the relevant information to the local farmers and authorities about the presence and mitigation measures so as to prevent environmental and health problems.

METHODOLOGY

Study area

'Lalri' is a region in Hamirpur District that is part of the study area. Lalri village has a population of 2358 people and a land area of 109.18 hectares. Fig. 1 illustrates the area selected for the current study.

Cropping system and soil sampling analysis

Potatoes, peas, and bitter gourd were selected as the three cropping systems. The chosen cropping systems were replicated six times, and uncultivated l and was used as a control group. Samples of soil

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Fig 1. Study area selected in the study

were taken from a variety of locations in order to determine the effects of nutrient availability, pH, electric conductivity and organic carbon concentration in the soil.

The analysis of the samples in the current research was conducted at the Chaudhary Sarwan Kumar Himachal Pradesh Krishi Vishwavidyalaya Agricultural University Palampur.

Sampling processing

To collect the soil samples, two depths were selected. The samples were collected from 0 to 15 cm of the surface and 15 to 30 cm of the subsurface. With the aid of a steel soil auger, soil samples were obtained from different depths. Using a wooden rod and a dryer, soil samples were pushed through a 2 mm sieve. After the collection, the samples were transported back to the lab for analysis. Table 1 and Fig. 2 lists the methodologies and tools utilized in this investigation.

Table 1. Equipment used to evaluate the different parameter in present study

Parameters	Instrument/Method used
pH	Glass electrode method (soil: water suspension 1:2.5)
Electrical conductivity	Soil water suspension (1:2)
Organic carbon	Walkey and Black (Rapid titration method)
Available nitrogen	Alkaline potassium permanganate method
Available phosphorus	Olsen’s method (Ascorbic acid reductant method)
Available potassium	Flame photometer

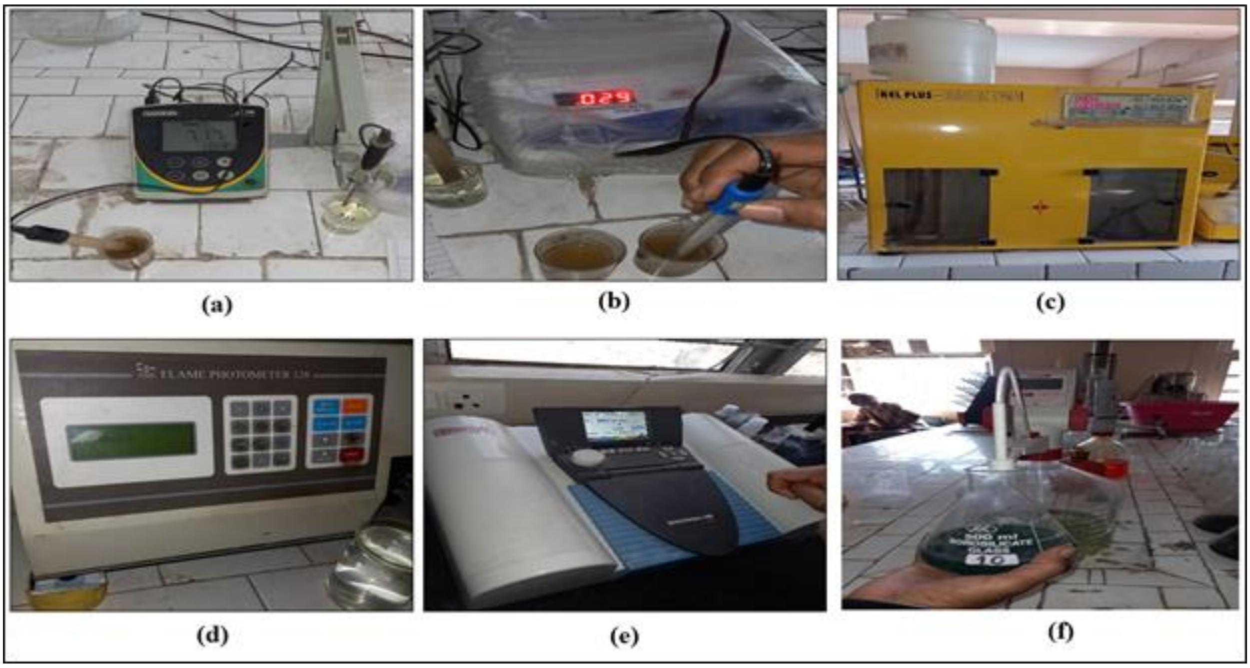

Fig. 2. (a) pH meter (b) Electrical conductivity meter (c) KEL Plus for available nitrogen (d) Flame photometer for potassium (e) Spectronic 200 for phosphorus (f) Rapid titration method for organic carbon

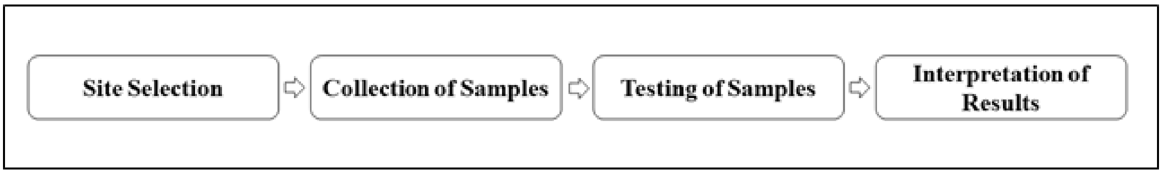

Fig. 3. Flowchart of the processes involved in the study

Sample testing

The analysis of the samples collected throughout the current study were conducted at the Chaudhary Sarwan Kumar Himachal Pradesh Krishi Vishwavidyalaya Agricultural University, Palampur. Fig. 3 represents the steps involved during the execution of the current study.

RESULTS AND DISCUSSION

Effect of pH

The pH values of the samples collected from the surface and subsurface layers ranged from 5.82-7.00 and 5.6-6.91, respectively. The pH of uncultivated agricultural soil has been reported to be around 6.34. The pH level of subsurface soil is lower than that of surface soil, although the overall systemic trend is the same. There is no correlation between soil pH and soil characteristics in different agricultural systems. Table 2 shows the findings of the pH of the soil at different sites.

Effect of electrical conductivity

Measured electrical conductivity in surface soil and subsurface soil was in the range of 0.024 to 0.070 ds $m^{-1}$and 0.018 to 0.051 ds m^{-1}, respectively. The electrical conductivity of crops is presented in sequence: Bitter gourd (0.070) > peas (0.055) > potatoes (0.041). Table 2 shows the findings of the electrical conductivity of soil at different locations. Electrical conductivity was found to be lower in subsurface soil than in surface soil. The samples from uncultivated agricultural soil shows electrical conductivity around 0.89 ds m^{-1}. The range of values for EC under different agricultural systems was typical and did not affect soil salinity concentrations. In the literature it has been stated by the researcher that the typical range of EC in agriculture soil can range from 0.05-0.7 ds m^{-1} [19].

Effect of organic carbon

For surface soil and subsurface soil, the organic carbon ranged from 1.99 to 2.53 % and 1.33 to 2.2%, respectively. Potatoes (2.533), peas (2.50), and bitter gourd (2.48) had the highest organic carbon values in soil. The control soil samples show organic carbon around 0.45% which is much less than the surface and subsurface values for all three edible products. Table 2 presents the organic carbon levels of soil samples collected from the different locations. Compared to surface soil, subsurface soil has a lower organic carbon value. Potato-based cropping had a greater percentage of organic carbon than other cropping systems. The main reason behind this is higher carbon stock is due to the use of long-term organic manure [20–22].

Available NPK

A major effect on soil nutrient availability has occurred in the research area's agricultural system. The findings of the NPK analysis of soils from different locations are provided in Table 3. Subsurface soil has a lower nutritional value than surface soil, regardless of the cropping schemes. Potatoes have a substantially larger amount of accessible nutrients than other crops due to the usage of inorganic fertilizers [22–24]. It has also been observed that the values of NPK samples of all three edible products were significantly more than the permissible limits and control samples [25].

CONCLUSION

The cropping patterns in Himachal Pradesh had a substantial impact on nutrient availability, organic carbon, and physical and chemical characteristics, according to the research. It was reported that the values of these parameters were greater than the permitted limits. NPK fertilisers and insecticides are heavily employed in the agricultural systems of the research area. There are a number of harmful effects on human health and on the environment as a result of excessive fertiliser use. In order to prevent future degradation of soil properties, it is necessary to regulate sustainable methods of soil management. To effectively fertilise the soil, the soil must first be thoroughly analysed. Fertilizer consumption should be reduced by educating farmers about the negative effects of fertilisers and pesticides on human and environmental health. Agrochemicals can be reduced in the agricultural sector by using manures, composts, and vermicompost that are organic.

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Table 2. The values of pH, electrical conductivity and organic carbon in the surface and subsurface soils

Cropping systems	pH			EC			OC		
	Control	Surface	Subsurface	Control	Surface	Subsurface	Control	Surface	Subsurface
	6.34 ±0.43			0.089 ±0.002			0.45 ±0.06		
Potatoes:									
Site 1		5.82 ±0.54	5.6 ±0.8		0.029 ±0.002	0.024 ±0.001		1.756 ±0.92	1.33 ±0.62
Site 2		6.16 ±0.34	6.37 ±0.56		0.041 ±0.005	0.038 ±0.004		2.42 ±0.54	2.1 ±0.35
Site 3		7 ±0.31	6.91 ±0.41		0.03 ±0.004	0.034 ±0.001		2.533 ±0.86	2.13 ±0.74
Peas:									
Site 1		6.22 ±0.85	6.03 ±0.49		0.04 ±0.004	0.026 ±0.003		2.47 ±0.35	2.07 ±0.33
Site 2		5.79 ±0.56	5.66 ±0.62		0.025 ±0.001	0.018 ±0.005		2.39 ±0.54	2.19 ±0.02
Site 3		6.53 ±0.37	6.41 ±0.54		0.055 ±0.006	0.04 ±0.001		2.5 ±0.86	2.26 ±0.25
Bitter Gourd:									
Site 1		6.65 ±0.64	6.56 ±0.43		0.024 ±0.002	0.02 ±0.001		2.48 ±0.56	2.07 ±0.32
Site 2		6.42 ±0.07	6.27 ±0.34		0.07 ±0.008	0.051 ±0.001		2.19 ±0.24	1.63 ±0.28
Site 3		6.51 ±0.54	6.39 ±0.65		0.039 ±0.002	0.031 ±0.004		1.93 ±0.61	1.7 ±0.46

Table 3. Status of available nutrient availability under different cropping in Himachal Pradesh

Cropping systems	Nitrogen (kg ha^{-1})			Phosphorus (kg ha^{-1})			Potassium (kg ha^{-1})		
	Control	Surface	Subsurface	Control	Surface	Subsurface	Control	Surface	Subsurface
	260.87 ±12			16.7 ±2.28			206.08 ±2.9		
Potatoes:									
Site 1		445.52 ±12.3	381.79 ±2.5		26.9 ±2.53	18.53 ±1.75		416.05 ±5.4	348.48 ±5.644
Site 2		505.1 ±9.54	387.6 ±6.31		31.55 ±3.51	26.13 ±2.4		415.68 ±2.93	357.87 ±4.65
Site 3		538.7 ±13.2	518.6 ±9.14		30.3 ±2.4	27.76 ±2.3		422.28 ±2.23	396.79 ±4.87
Peas:									
Site 1		515.63 ±3.64	456.03 ±6.26		31.18 ±3.6	26.16 ±1.1		386.03 ±3.28	343.48 ±2.65
Site 2		521.66 ±4.1	477.92 ±3.5		28.53 ±2.2	24.28 ±1.97		419.32 ±2.92	357.76 ±6.2
Site 3		495.54 ±9.34	464.1 ±2.31		29.79 ±4.2	23.08 ±1.093		357.68 ±6.2	333.65 ±10.2
Bitter Gourd:									
Site 1		497.26 ±5.23	467.66 ±6.39		30.48 ±2.94	24.52 ±3.1		383.8 ±4.1	367.42 ±1.7
Site 2		515.73 ±3.63	463.34 ±2.4		27.4 ±2.34	19.66 ±0.63		364.8 ±7.63	365.76 ±3.3
Site 3		489.73 ±8.32	428.51 ±5.22		28.93 ±2.12	25.6 ±1.9		418.23 ±6.2	386.13 ±0.63

REFERENCES

1. P. Joshi, T. Trivedi, R. Sharma, S. Verma, V. Bharti, K. Gyota, ICAR's Vision 2030, 2011.
2. GRISP, Rice Almanac, 4th edn., International Rice Research Institute, Los Baños, Philippines, 2013.
3. M.N. Almasri, J.J. Kaluarachchi, *J. Hydrol.*, **295,** 225 (2004).
4. P.F. Hudak, *J. Hydrol.* ***228,*** 37 (2000).
5. S. Savci, Int. J. Environ., *Sci. Dev.*, **3,** 73 (2012).
6. L. Horrigan, R.S. Lawrence, P. Walker, *Environ. Health Perspect.*, **110,** 445 (2002).
7. *Planning Commission,* 2002, p. 1.
8. P.K. Gupta, *Toxicology*, **198,** 83 (2004).
9. WHO, Public Health Impact of Pesticides Used in Agriculture, 1990.
10. .R. Institute, Environmental Change and Human Health, World Resources 1998-1999, 1998.
11. *U. Seeds,* 2021.
12. ICAR, Indian Counc. Agric. Res. (n.d.).
13. CEIC, Dep. Agric. Coop. (n.d.).
14. A.A. Al-Zaidi, E.A. Elhag, S.H. Al-Otaibi, M.B. Baig, *J. Anim. Plant Sci.*, ***21,*** 605 (2011).
15. K.A. da Silva, V.B. Nicola, R.T. Dudas, W.C. Demetrio, L. dos S. Maia, L. Cunha, M.L.C. Bartz, G.G. Brown, A. Pasini, P. Kille, N.G.C. Ferreira, C.M.R. de Oliveira, *Sci. Rep.*, **11,** 1 (2021).
16. Y.L. Wei, L.J. Bao, C.C. Wu, Z.C. He, E.Y. Zeng, *Sci. Total Environ.*, **514,** 409 (2015).
17. B. Yargholi, S. Azarneshan, *Int. J. Agric. Crop Sci.*, **7,** 518 (2014).
18. S. Kumari, H. Sharma, *Int. J. Sci. Res.*, **3** 144 (2014).
19. N. Loria, S.K. Bhardwaj, C.K. Ndungu, *J. Appl. Nat. Sci*., **8,** 1479 (2016).
20. B.S. Brar, J. Singh, G. Singh, G. Kaur, *Agronomy*, 220 (2015).
21. L. Chen, X. Qi, X. Zhang, Q. Li, Y. Zhang, *Chinese Geogr. Sci*., **21** 392 (2011).
22. J. Tian, M. Fan, J. Guo, P. Marschner, X. Li, Y. Kuzyakov, *Eur. J. Soil Biol.*, **52,** 67 (2012)
23. J. Kimigo, P. Gicheru, *Pedologist*, **55,** 326 (2012).
24. N. Nisar, F.A. Lone, *J. Res. Earth Environ. Sci.*, **1,** 13 (2013).
25. AgriTech, Rat. Chart Soil Test Data (n.d.).